Details of each benchmark line

Sho Iwamoto

Details (fail safe note) for each of my analyses.

$$\tilde{l}_\mathrm{L} = (\tilde{e}_\mathrm{L}, \tilde{\mu}_\mathrm{L}, \tilde{\tau}_\mathrm{L}), \qquad \tilde{\nu} = (\tilde{\nu}_e, \tilde{\nu}_\mu, \tilde{\nu}_\tau), \qquad \text{slepton} = (\tilde{l}_\mathrm{L}, \tilde{\nu}, (\tilde{l}_\mathrm{R})),$$
$$l = (e, \mu, \tau), \qquad \ell = (e, \mu), \ldots$$

1 Decay chain categorization

$$\text{chain-3L} : \tilde{\chi}^0\tilde{\chi}^+ \to (\tilde{l}_\mathrm{L}\nu; 1/3 \text{ each}) + (\tilde{l}_\mathrm{L}^{(*)} l^{(*)} \text{ or } \tilde{\nu}^{(*)}\tilde{\nu}^{(*)}; 1/12 \text{ each}) \otimes (\tilde{l}_\mathrm{L} \to l\tilde{\chi}^0_\mathrm{LSP}, \tilde{\nu} \to \nu\tilde{\chi}^0_\mathrm{LSP}; 100\%) \tag{1.1}$$

ATLAS 1803 analyzes Chain 3L by "a statistical combination of the five SR3-slep regions." The SRs require three signal lepton (ℓ)[*1], where the lepton ℓ may as well come from leptonic tau decays.

2 tab1-0.50

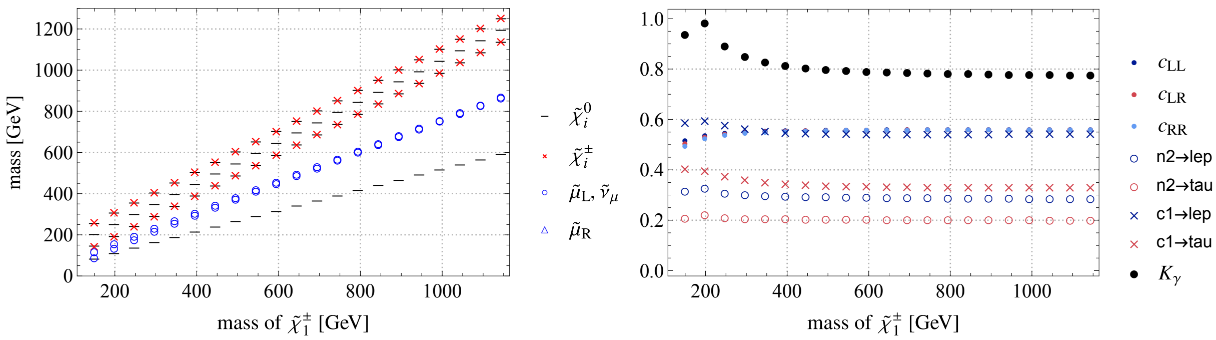

Figure 1: Mass spectrum and c-factors of tab1-0.50 benchmark line. The models are generated with $M_2 = 200, 250, \ldots, 1200\,\mathrm{GeV}$, while $m_{\tilde{\chi}_1^\pm}$ is used to label.

This line is characterized by

$$M_2 = \mu = 2M_1, \quad x = \frac{m_{\tilde{l}_\mathrm{L}} - m_{\tilde{\chi}_1^0}}{m_{\tilde{\chi}_2^0} - m_{\tilde{\chi}_1^0}} = 0.5, \quad \tan\beta = 40, \quad \tilde{l}_\mathrm{R}, \tilde{q}, \text{heavy-Higgs: decoupled.} \tag{2.1}$$

The mass spectrum is shown below, and we use $m_{\tilde{\chi}_1^\pm}$ (in GeV) as the label of each model point.

P<300 is not considered in our analysis, as neither by ATLAS. P150 has $\tilde{\nu}$-LSP.

In P≥300, $\tilde{\chi}_2^0\tilde{\chi}_1^\pm$ mainly produces chain-3L. Also, $\tilde{\chi}_{3,4}^0$ and $\tilde{\chi}_2^\pm$ decays similarly. We safely ignore $\tilde{\chi}_3^0$ because of non-degeneracy and, as it has less $\tilde{W}$-component, smaller production rate. A degenerate pair $\tilde{\chi}_4^0\tilde{\chi}_2^\pm$ may serve as the chain-3L target. At this first stage I will ignore it, but it may be interesting to include the effect (but how?).

The c-factors are similar and thus we use the factor

$$K_\sigma = \mathrm{mean}(c_\mathrm{LL}, c_\mathrm{LR}, c_\mathrm{RR}) \tag{2.2}$$

[*1] Note that they do not define "signal tau."

to compensate the difference in production cross section from pure-wino (ATLAS 1803) case. We thus estimate the production cross section as

$$\sigma(pp \to \tilde\chi^0_2\tilde\chi^\pm_1) \approx K_{\mathrm{sigma}} \cdot \sigma(pp \to \tilde W^\pm \tilde W^3), \tag{2.3}$$

where the pure-wino production cross section $\sigma(pp \to \tilde W^\pm \tilde W^3)$ is taken from LHCSUSYXSWG[*2].

The decays of $\tilde\chi^0_2\tilde\chi^\pm_1$ does not equally branch because of Yukawas and slepton mass differences;

$$\tilde\chi^0_2: \quad \tau > e = \mu \gtrsim \nu_e = \nu_\mu = \nu_\tau \quad \text{(also to } Z,\, H\text{)}, \tag{2.4}$$

$$\tilde\chi^\pm_1: \quad \tau > e = \mu \gtrsim \nu_\tau \gtrsim \nu_e = \nu_\mu \quad \text{(also to } W^\pm\text{)}. \tag{2.5}$$

In ATLAS analysis, since the $\tilde\chi^0_2\tilde\chi^\pm_1$ pair is pure-Wino and sleptons masses are degenerate, three-ℓ signature is expected by a probability of

$$\left(\frac{2}{3} + \frac{1}{3}p(\ell|\tau)\right)\left(\frac{4}{12} + \frac{2}{12}p(\ell|\tau)\right) \approx 0.307, \tag{2.6}$$

where $p(\ell|\tau) \simeq 0.352$ is the leptonic decay rate of τ. We therefore compensate the difference in the branching ratios with K_Γ-factor:

$$K_\Gamma = \frac{1}{0.307}\left[p(\tilde\ell_{\mathrm{L}}, \tilde\nu_\ell|\tilde\chi^\pm_1) + p(\ell|\tau)p(\tilde\tau_{\mathrm{L}}, \tilde\nu_\tau|\tilde\chi^\pm_1)\right]\left[p(\tilde\ell^{(*)}_{\mathrm{L}}|\tilde\chi^0_2) + p(\ell|\tau)p(\tilde\tau^{(*)}_{\mathrm{L}}|\tilde\chi^0_2)\right] \tag{2.7}$$

(the notation $p(\text{daughters}|\text{mothers})$ should be understood). Here one should note that we ignore the kinematics difference due to the origin of lepton (whether τ, $\tilde\chi$, or sleptons) as well as slepton non-degeneracy.

We then compare our cross section with σ_{UL}; the points with

$$\frac{K_\sigma K_\Gamma \cdot \sigma(pp \to \tilde W^\pm \tilde W^3)}{\sigma_{\mathrm{UL}}} \geq 1 \tag{2.8}$$

are excluded.[*3]

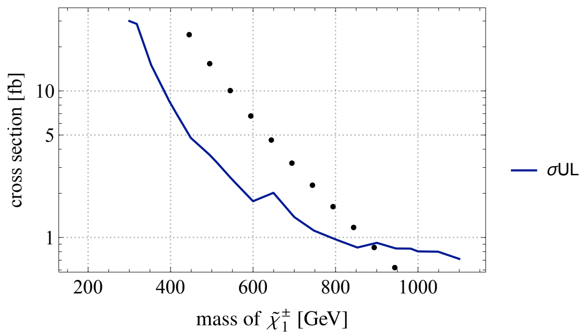

Figure 2: ATLAS 1803 analysis (3l-slep) on tab1-0.50 benchmark line.

The results against ATLAS1803 is shown in Fig. 2, where the black dots correspond to $K_\sigma K_\Gamma \sigma(\text{Wino})$. It shows that the ATLAS 1803 analysis nearly excludes P900 (and below). The wiggles in σ_{UL} is due to interpolation of the σ_{UL}-grid ATLAS provides, for which logarithmic interpolation (i.e., linear interpolation on the function $\log \sigma_{\mathrm{UL}}(m_{\tilde\chi^\pm_1}, m_{\tilde\chi^0_1})$) is used.

References

[*2] `https://twiki.cern.ch/twiki/bin/view/LHCPhysics/SUSYCrossSections13TeVn2x1wino`

[*3] ATLAS 1803: `https://doi.org/10.17182/hepdata.81996.v1/t80`